Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

Issued April 8, 1912.

United States Department of Agriculture,

BUREAU OF CHEMISTRY—Circular No. 96.

H. W. WILEY, Chief of Bureau.

A MEASUREMENT OF THE TRANSLUCENCY OF PAPERS.

By C. Frank Sammet,

Assistant Chemist, Leather and Paper Laboratory.

That property of paper which permits light to pass through it is usually spoken of as its transparency. Although this term can not be concisely defined, it more commonly refers to the transmission of the greater portion of incident light through matter without scattering. Paper is of such a discontinuous nature that light in transmission is always more or less scattered. This characteristic is more definitely expressed by the word "translucency," which is, therefore, to be preferred to "transparency." "Opacity," the inability to transmit light, can not properly be used to express the degree of translucency or transparency of paper.

Translucency is quite an important property of paper, especially of printing, envelope, pergamene, and so-called transparent papers. The first two classes should not be so translucent that printing or writing will show through sufficiently either to inconvenience or to tire the eye, while the latter kinds should be so nearly transparent that characters may be easily and quickly read through them. Many procedures have been suggested for the measurement of translucency, but few of them have proved to be of any practical significance and, as a rule, they have given only comparative results. A numerical expression is desired which will be standard in the valuation of the translucency of papers as established by the normal eye.

The most satisfactory instrument heretofore proposed for this measurement is the grease-spot photometer.[1] This consists of two lights of equal intensity with a spot screen equidistant between them. The paper to be examined is placed between the screen and one of the lights. The latter is moved until the light falling upon the screen is the same from both sides. The ratio of the distances of the lights from the screen is an expression of the translucency of the paper (Böhm's method).

The instrument devised by Klemm, in which successive sheets of the paper are inserted until the light from a 1-candlepower Hefner burner is cut off, is totally unsuitable to express the translucency of

[1] Wochenblatt für Papierfabrikation, 1910, 41: 4404; Papier Zeitung, 1908, No. 50; Klemm, Handbuch der Papierkunde, 2. aufl., p. 323–325.

paper when it is looked *at* rather than *through*. Serious inaccuracies arise with this instrument due to differences in surface, color in the paper, the transmission of light through more than one sheet and across intervening air spaces, and the retention of color sense by the eye, any one of which produces wide variations and in some instances a reversal of the sequence of translucency. It also gives inaccurate results on colored papers, and, furthermore, it measures the light transmitted through the paper once, while ordinarily that which has been transmitted to the eye after reflection from a surface underneath is the light which it is desired to measure.

The procedure to be described is free from the foregoing objections, and for practical purposes determines any degree of translucency, in white as well as colored papers, in terms of a standard. When a paper is placed over a white surface the luminosity observed is composed of the light reflected from the surface of the paper plus that which is reflected from the surface underneath. When the paper is placed on a perfectly black surface the luminosity is that of the light reflected from the surface of the paper only as the transmitted light has been absorbed. The difference of the values which measure these two effects gives an expression for the light transmitted, and therefore for the translucency of the paper. These measurements may be obtained by means of the tint photometer, which is constructed and operated as follows:

Two blocks of magnesium carbonate are used as a standard white background. A piece of black velvet is most satisfactory as a black or absorbing background. The rays of the sun diffused through tracing cloth or white paper evenly illuminate the white surfaces of the blocks. These are viewed in a mirror on reflection through two apertures, which are focused by a specially ground lens into semicircular fields. One aperture is controlled by a shutter operated by a lever that reads 100 when wide open and zero when closed on a scale divided into millimeters, whereby any degree of luminosity may be obtained. In order to counteract the confusing impression different kinds of surfaces may have on the eye, the light is passed through a series of revolving lenses, thus producing uniform fields. It would be rather difficult to match the luminosity of fields of different tints, and to eliminate this effect the fields are viewed through a colored glass of some primary color. The luminosity observed is inappreciably affected thereby in the case of white papers, and the same is true with those of deep tints, if the measurements are made through a glass of the primary color representative of the predominating hue of the paper. Red, green, and blue glasses have proved satisfactory.

After the fields are matched the black velvet background is placed over one block. The paper whose transparency is to be determined

is then placed over both blocks. By operating the shutter the luminosity of the lighter field (due to the light reflected from the surface of the paper plus the transmitted light reflected from the surface of the block underneath) is reduced until it matches that of the field with the black velvet background, the luminosity of which is due to the light reflected from the surface of the paper only, as the transmitted light has been absorbed. Hence the value of the lowering of the reading (100—the reading observed) is a measure of the transmitted light reflected from the surface underneath, i. e., of the translucency of the paper. Care should be taken to match the fields before a reading is taken. The paper should be in immediate contact with the background. The colored glass used in the reading should be as near a pure primary color as possible. Check results can be obtained within one division of the scale.

The proposed method gives more satisfactory results than those previously suggested, especially in the case of colored papers, and is perhaps more convenient in manipulation. The result gives the translucency usually sought, namely, the transmission of light through the paper and reflection from the surface underneath, while the other photometer methods indicate the direct transmission. No errors of sufficient magnitude to interfere with the sequence of translucency as established by the normal eye have been observed. The figures in the second column express the translucency of the paper as determined by the proposed procedure. They also express directly the percentage of incident light transmitted through the paper and reflected back through it by the standard white surface upon which it rests. The results obtained by the proposed method and by the Böhm method are given in the table. The readings are on papers which range, to the normal eye, from very translucent to almost opaque.

Determinations[1] of the translucency of papers by two methods.

Kind of paper.	Order according to normal eye.	Proposed method (100—reading).	Photometer method of Böhm[1] calculated by formula $(1-\frac{b^2}{a^2})100$.	Kind of paper.	Order according to normal eye.	Proposed method (100—reading).	Photometer method of Böhm[1] calculated by formula $(1-\frac{b^2}{a^2})100$.
Japanese press copy (white)	1	66	34.5	Filter (white)	9	25	65.5
Parchment (cream)	2	58	33.5	Bond (yellow)	10	20	68.0
Press copy (brown)	3	55	49.5	Bible (cream)	11	18	68.0
Glazed onionskin (white)	4	40	54.5	Ledger (white)	12	18	69.0
Typewriter (white)	5	37	60.0	Do	13	17	70.0
Bond (pink)	6	32	65.5	Writing, linen finish (blue)	14	16	68.0
Typewriter (white)	7	28	64.5	Laid envelope (white)	15	14	69.5
Bond (orange)	8	27	67.5	Scratch pad (white)	16	2	79.5

[1] Loc. cit.

ADDITIONAL COPIES of this publication may be procured from the SUPERINTENDENT OF DOCUMENTS, Government Printing Office, Washington, D. C., at 5 cents per copy